CHEMICAL RESIDUE CONTENT AND HATCHABILITY OF SCREECH OWL EGGS

Erwin E. Klaas and Douglas M. Swineford

A close relationship between organochlorine insecticide residues in avian tissues and eggs and reduced reproductive efficiency has been demonstrated for a variety of species, both in controlled experiments and in field situations (Cooke 1973). Poor reproduction is generally accompanied by the production of eggs with reduced shell weight and thickness (Hickey and Anderson 1968, Enderson and Berger 1970, Ratcliffe 1970). Certain birds of prey, because of the high percentage of birds in their diet, seem to be particularly vulnerable to contamination, and recent declines in population numbers have occurred in certain areas where organochlorine residues in eggs or tissues are found to be high (Fyfe et al. 1969, Cade et al. 1971).

No assessment has been made of chemical residues in wild Screech Owls (*Otus asio*) in North America. These small birds of prey are at the top of their food chain, and feed on a wide variety of prey including crustacea, insects, small mammals, and birds. In a controlled study with captive Screech Owls, McLane and Hall (1972) demonstrated that 2.8 ppm (wet wt.) of DDE mixed in the diet would reduce eggshell thickness an average of 12%. Hence, we thought it possible that chemical residues might accumulate to relatively high levels in Screech Owls in nature.

This study was undertaken to obtain baseline information on organochlorine residues in the eggs of wild Screech Owls, to determine whether eggshell thinning is occurring, and to attempt to associate chemical residues with hatching failures in individual clutches. The population occurring in northwestern Ohio was selected for study because data concerning food habits and reproductive success over a 30-year period were available for the area (VanCamp and Henny 1976). Many of the owls in VanCamp's study area nested in artificial nest boxes and were easily accessible for acquiring a statistically adequate sample of nests. Moreover, many of the owls used in McLane and Hall's (1972) study were acquired from this area.

METHODS

In 1973, 19 nests were located during egg-laying or the early stages of incubation. Soon after laying was completed, 1 egg was removed from each clutch. Nests were revisited after young had hatched and 14 unhatched (addled) eggs were collected. Four other nests were found for the first time after young had hatched. Each of these nests contained 1 addled egg, 2 of which were collected and are included in discussions of unhatched eggs.

Collected eggs were refrigerated until the contents could be removed and placed in bottles that had been rinsed in hexane and acetone. Caps for the bottles were lined with aluminum foil. Samples were then frozen (–8°C) until they could be analyzed for residues.

Eggshells were rinsed with cold water and allowed to air dry at ambient temperatures for about 3 months before measuring. Shell thickness was measured with a Starrett Model 1010M dial gauge graduated in 0.01 mm increments. This same gauge, modified to measure archival eggshells having a small blow-hole, was used to measure eggs collected prior to 1935 that are presently in various museum collections. The thickness of each eggshell was determined as the mean of 3 measurements taken near the equator.

The contents of the owl eggs, albumen and yolk, were prepared for chemical analyses by homogenization. A 5-g aliquot of the homogenate was mixed with anhydrous sodium sulfate and extracted for 7 h with hexane in a Soxhlet apparatus. The extract was cleaned up on a Florisil column. Organochlorine pesticides and polychlorinated biphenyls (PCB's) were separated into 3 fractions on a Silicar column and analyzed by electron capture gas chromatography on a 4% SE–30/6% QF-1 column. The lower limit of sensitivity was 0.10 ppm. Eggs were analyzed for p,p′-DDE, p,p′-DDD, p,p′-DDT, dieldrin, heptachlor epoxide, mirex, oxychlordane, *cis*-chlordane and/or *trans*-nonachlor, *cis*-nonachlor, hexachlorobenzene (HCB) and PCB's. Average recovery of spiked Mallard (*Anas platyrhynchos*) carcass tissue ranged from 96% to 110% for all compounds, except hexachlorobenzene which had an average recovery of 69%. Residues in 10% of the samples were confirmed on a combined gas chromatograph-mass spectrometer. A more detailed description of the analytical procedure is presented by Cromartie et al. (1975). Residues were adjusted to fresh wet weight, assuming specific gravity of 1.0 as suggested by Stickel et al. (1973).

Analysis of variance and t-tests followed procedures given in Sokal and Rohlf (1969).

RESULTS

Eggshell thickness.—Thickness measurements from 2 groups of archival eggs (1 egg selected at random from each of 12 clutches from Ohio, and 37 clutches from Pennsylvania) were compared with thicknesses of 19 eggs (collected early in incubation from 19 clutches) from northwestern Ohio in 1973. No statistical differences were detected in the means for the 3 groups of eggs (anova, $p > 0.50$). A 4th group of 16 unhatched eggs (11 of which came from 3 clutches in which no eggs hatched) from 8 clutches did not differ in mean thickness from the other 3 groups (Table 1).

Chemical residues and nesting success.—DDE and PCB's occurred in all 35 Screech Owl eggs analyzed. These eggs were laid by 21 different females. The mean level of DDE was 1.29 ppm (range, 0.33–2.8) and PCB's averaged 1.32 ppm (range 0.26–3.4). Dieldrin averaged 0.13 ppm (range, 0.10–0.24) in 8 eggs, each from a different clutch. Other organochlorines detected among the 35 eggs analyzed are given in order of frequency: Mirex (5 eggs from 3 clutches, $\bar{x} = 0.12$ ppm), HCB (3 eggs from 3 clutches, $\bar{x} = 0.11$), DDD (2 eggs from 2 clutches, 0.12 and 0.11 ppm),

TABLE 1

SHELL THICKNESS (MM) FOR SCREECH OWL EGGS COLLECTED IN OHIO AND PENNSYLVANIA

Locality	Collected	Eggs measured	Mean	S.E.	Range
Pennsylvania	Pre-1947	37	0.241	0.003	0.197–0.277
Ohio	Pre-1947	12	0.244	0.004	0.230–0.287
Ohio (early[1])	1973	19	0.234	0.004	0.197–0.260
Ohio (addled)	1973	16	0.243	0.007	0.157–0.270

[1] Eggs collected early in incubation.

heptachlor epoxide (2 eggs from 2 clutches, 0.10 and 0.22 ppm), DDT (1 egg, 0.19 ppm), oxychlordane (1 egg, 0.31 ppm) and *cis*-chlordane (1 egg, 0.20 ppm).

The 19 nests located at the start of the nesting season contained an average of 4.6 eggs per nest. After collecting 1 egg from each nest, 68

TABLE 2

NESTING SUCCESS OF SCREECH OWLS IN NORTHERN OHIO IN 1973 AND RESIDUES OF DDE AND PCB'S IN THEIR EGGS

No. of nests	Eggs laid[1] per nest	Young fledged per nest	Unhatched eggs per nest	Early or unhatched	No. of eggs	ppm, Wet Wt.[2]	
						DDE	PCB's
2	6	5	1	—	—	—	—
1	6	3	0	Early	1	2.8	2.8
1	6	1	4	Early	1	0.81	0.88
				Unhatched	4	(0.96)	(1.03)
1	6	0	5	Early	1	1.5	1.4
				Unhatched	3	(1.63)	(1.40)
5	5	4	0	Early	5	(0.93)	(0.93)
1	5	0	4	Early	1	1.7	1.3
				Unhatched	4	(1.45)	(1.18)
5	4	3	0	Early	5	(1.74)	(2.05)
2	4	2	1	Early	2	(1.23)	(0.80)
				Unhatched	2	(0.73)	(0.63)
1	4	1	Unknown	Early	1	0.63	0.54
1	4	0	Unknown	Early	1	1.3	2.1
1	3	1	1	Early	1	0.89	0.51
				Unhatched	1	0.47	0.26
1	Unknown	2	1	Unhatched	1	2.1	3.4
1	Unknown	Unknown	1	Unhatched	1	1.2	2.2

[1] Represents number of eggs before 1 was removed for analysis.
[2] Values in parentheses are arithmetic means; estimated variances based on total sample: DDE, 0.322; PCB's, 0.651.

eggs remained. A total of 49 eggs (72%) hatched, or an average of 2.6 per nest. An average of 2.5 owls fledged per nest and 16 of the 19 nests produced at least 1 young. Fourteen eggs (in 6 clutches) failed to hatch and were recovered, 5 eggs disappeared near the time of hatching and may have hatched, and 2 young disappeared.

DDE residues averaged 1.2 ppm in 16 unhatched eggs and 1.3 ppm in 19 eggs collected early in incubation. PCB's averaged 1.2 ppm in unhatched eggs and 1.4 in eggs collected early in incubation. Neither of these differences in means was significant (t-tests, $P > 0.10$). Also, mean residue levels of DDE and PCB's in 11 eggs collected early in incubation from nests in which all of the remaining eggs were known to have hatched were not different statistically ($P > 0.01$) from residue levels in unhatched eggs. (PCB chromatograms most closely resembled a profile for Aroclor 1260.)

One egg containing residues of 7 different compounds totaling 3.4 ppm came from a nest in which all 4 remaining eggs in the nest hatched. In another instance, an egg contained 5 compounds totaling 3.8 ppm but the 3 remaining eggs in this nest disappeared before hatching.

The 2 nestlings that disappeared were survived by 3 nestmates and we doubt that their loss was related to residue levels. Yet, the egg analyzed from this nest contained the highest level of total organochlorines (5.88 ppm) found during the study.

DISCUSSION AND CONCLUSIONS

No apparent relationship was found between hatching failures and the presence of organochlorine residues in eggs from a wild population of Screech Owls. Moreover, eggshell thickness in 1973 was unchanged from that of eggs collected before the widespread use of organochlorine pesticides. Although the shells of Screech Owl eggs can be experimentally thinned by feeding low levels of DDE in the birds' diet (McLane and Hall 1972), the wild owls examined in this study are apparently not accumulating enough residues in their tissues to cause any adverse effects on shell thickness or hatchability. Also, mean DDE residues are below the levels that have been associated with detrimental effects on reproduction in other raptorial species (Fyfe et al. 1969, Cade et al. 1971, Snyder et al. 1973, Wiemeyer et al. 1975). The Ohio Screech Owls have sustained good reproductive rates and stable numbers for many years (VanCamp and Henny 1976). Thus, it is probable that residue levels have never been much higher than those found in 1973.

The relatively low residue levels are consistent with the healthiness of the population. The owls nest principally in narrow strips of riparian habitat bordering streams that drain large areas of cropland (corn, wheat, soybeans). Although specific information concerning pesticide use in this area was not obtained, it is generally known that DDT and dieldrin were widely used to control pests on these grain crops throughout the midwestern United States for many years. Thus, it is surprising that higher residue levels were not found since most of these chemicals are known to be persistent and widespread, and to accumulate in food chains. Also, Screech Owls are at the top of their food chain. A possible explanation is that the Screech Owl preys on a wide variety of animals, some of which are less contaminated than others. VanCamp and Henny (1976) show that small birds make up a large portion of the Screech Owl's diet in spring and may be the major source of contamination; in other seasons, mammals and invertebrates are more important. The latter forms could be expected to carry lower residue levels than birds, allowing for a period in which tissue levels could be reduced through metabolism and excretion.

SUMMARY

Eggs of wild Screech Owls were collected from nests in northwestern Ohio in 1973. One egg was taken from each of 19 nests near the start of incubation. Mean shell thickness in these 19 eggs and mean thickness of 16 unhatched eggs did not differ from 49 archival eggs collected in Ohio and Pennsylvania prior to the widespread use of organochlorine pesticides. Residues were generally low although all eggs contained DDE and PCB's. No relationship was found between hatching failures and the presence of organochlorine residues. Low residues are consistent with a long history of good nesting success and a stable population.

ACKNOWLEDGMENTS

We wish to thank Charles J. Henny, who suggested the study, and Laurel VanCamp, who collected the eggs and supplied the information on nest success. Harry Ohlendorf assisted in preparing the eggs for analysis and in measuring museum eggs. Robert Heath provided helpful suggestions on analysis and interpretation of the data. We appreciate critical reviews of the manuscript by Eugene H. Dustman and Rey C. Stendell.

We acknowledge also the cooperation of curatorial personnel in the following museums where oological collections were examined: American Museum of Natural History, Carnegie Museum, Clemson University, Delaware Museum of Natural History, Florida State Museum, Louisiana State University, Museum of Comparative Zoology, Peabody Museum of Natural History, Philadelphia Academy of Natural Sciences, University of Kansas, University of Massachusetts, and U.S. National Museum.

LITERATURE CITED

Cade, T. J., J. L. Lincer, C. M. White, D. G. Roseneau, and L. G. Swartz. 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Science 172: 955–957.

Cooke, A. S. 1973. Shell thinning in avian eggs by environmental pollutants. Environ. Pollut. 4:85–152.

Cromartie, E., W. L. Reichel, L. N. Locke, A. A. Belisle, T. E. Kaiser, T. G. Lamont, B. M. Mulhern, R. M. Prouty, and D. M. Swineford. 1975. Residues of organochlorine pesticides and polychlorinated biphenyls and autopsy data for Bald Eagles, 1971 and 1972. Pestic. Monit. J. 9:1–58.

Enderson, J. H. and D. D. Berger. 1970. Pesticides: eggshell thinning and lowered production of young in Prairie Falcons. BioScience 20:355.

Fyfe, R. W., J. Campbell, B. Hayson, and K. Hodson. 1969. Regional population declines and organochlorine insecticides in Canadian Prairie Falcons. Can. Field-Nat. 83:191–200.

Hickey, J. J. and D. W. Anderson. 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science 162:271–273.

McLane, M. A. R. and L. C. Hall. 1972. DDE thins Screech Owl eggshells. Bull. Environ. Contam. and Toxicol. 8:65–68.

Ratcliffe, D. A. 1970. Changes attributable to pesticides in egg breakage frequency and eggshell thickness in some British birds. J. Appl. Ecol. 7:67–115.

Snyder, N. F. R., H. A. Snyder, J. L. Lincer, and R. T. Reynolds. 1973. Organochlorines, heavy metals, and the biology of North American accipiters. BioScience 23:300–305.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Co., San Francisco.

Stickel, L. F., S. N. Wiemeyer, and L. J. Blus. 1973. Pesticide residues in eggs of wild birds: adjustment for loss of moisture and lipid. Bull. Environ. Contam. and Toxicol. 9:193–196.

VanCamp, L. F. and C. J. Henny. 1976. The Screech Owl: Its life history and population ecology in northern Ohio. N. Am. Fauna, No. 71.

Wiemeyer, S. N., P. R. Spitzer, W. C. Krantz, T. G. Lamont, and E. Cromartie. 1975. Effects of environmental pollutants on Connecticut and Maryland Ospreys. J. Wildl. Manage. 39:124–139.

U.S. FISH AND WILDLIFE SERVICE, PATUXENT WILDLIFE RESEARCH CENTER, LAUREL, MD. 20811 (PRESENT ADDRESS: EEK, IOWA COOPERATIVE WILDLIFE RESEARCH UNIT, AMES 50011). ACCEPTED 1 MAR. 1976. PAGE COSTS PAID.